Resource Management: A Necessary and Integral Component to Any Level 2/3 Fusion Capability

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Abstract – *Process Refinement or feedback is a key component of any closed loop system. Fusion models are no exception. In this paper we will explore what process refinement means in terms of the higher levels of fusion. In doing so we further refine the existing definitions of the various levels (as defined by the Joint Director of Laboratories, JDL) and based on these definitions we discuss how each of these levels interacts with each other.*

Keywords: Process Refinement, Fusion, JDL, Endsley, Situation Awareness, Situation Assessment, Impact Assessment, Threat Assessment, Projection, Anticipation

1 Background

Process Refinement, as defined by the JDL panel, is an ongoing monitoring and assessment of the fusion process to refine the process itself and to regulate the acquisition of data to achieve optimal results (Klein, 1993). Level 4 (Process Refinement) interacts with each of the other levels. But what does this mean? How does it interact? Past work has concentrated on Level 0 (Sub-Object Data Assessment) and 1 (Object Assessment) and their interaction with Level 4, but little has been accomplished between Level 4 and the higher levels – 2 (Situation Assessment) and 3 (Impact or Threat Assessment). We begin our discussion with a number of basic definitions from which we will refine the existing JDL definitions. After we present our view, we next show where and how process refinement fits into the overall framework. We conclude this paper with a number of issues and challenges.

1.1 What is Level 2/3 Fusion?

There continues to be a debate as to what Levels 1 and 2 represent. One belief is that Level 1 deals only with the tracking and identification of individual objects while Level 2 is the aggregation of the objects into groups or units. For example, Level 1 objects could be various equipments (tanks, APCs, missiles, etc). At Level 2, equipment along with personnel can be aggregated into a unit or division based on time and space. But if we consider this separation then several questions arise; how do we account for concepts or non-physical objects and can't we track a group or activity like an object? What is a situation? How does the system acquire the necessary a

priori knowledge (or relationships) to perform aggregation? What is the difference between models for identifying an object, a group or an activity? To begin to answer these questions we first present a number of basic definitions and then use them to refine what we mean by Level 1 and 2. We then will explore the difference between Level 2/3 and what Endsley [4] presents as Projection.

Wikipedia defines an **entity** as "something that has a distinct, separate existence, though it need not be a material existence. In particular, abstractions and legal fictions are usually regarded as entities. In general, there is also no presumption that an entity is animate. The word *entity* is often useful when one wants to refer to something that could be a human being, a non-human animal, a non-thinking life-form such as a plant or fungus, a lifeless object, or even a belief; for instance, one could say that any entity that enters a black hole would be transported, in many pieces, to another dimension." An **object** is "a physical entity; something that is within the grasp of the senses" (Wikipedia); "something perceptible by one or more of the senses, especially by vision or touch" (The Free Dictionary). What if the entity is not a physical object? How can we describe it? Generally speaking, an abstract entity still can be associated with a time or existence and an abstract concept.

A **group** is "a number of things (entities, to include individuals) being in some relation to each other" while an **event** is "something that takes place; an occurrence at an arbitrary point in time; something that happens at a given place and time" (Wikipedia). Both entities and groups can be associated with a specific event or events. An **activity** is "something done as an action or a movement" (Wikipedia). Activities are composed of entities/groups related by one or more events over time and/or space.

Thus by definition an event, group and activity can be considered as a more complex entity (or in terms of the JDL, an object) and can be tracked and identified. As a side note, the JDL Lexicon does define an entity as "Any object or object set (or event or event set) which forms the basis of a hypothesis used in data fusion processes" but does not define what an object or event is. Now back to our discussion, by using the definitions presented above, we argue that activities and the aggregation of these activities (which we refer to as the situation) is both a part and a result of Level 1. Models or a priori knowledge is necessary for level 1 to be capable of identifying the object, group or activity. This a priori knowledge (i.e., the

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relationships or associations) that can be learned through Knowledge Discovery and validated by an operator or provided directly. Here we note that Knowledge Discovery techniques can only learn statistically relevant occurrences. As such, new or novel ideas cannot be learned and require knowledge elicitation.

Level 2 is then the assessment of the situation at that snapshot in time. This includes the interpretation or meaning of what is happening with respect to context and time while Level 3 is the determination of whether there exists a threat or impact – is there an entity, group, event or activity that we should care about? Specifically, situation assessment is a quantitative evaluation of the situation that has to do with the notions of judgment, appraisal, and relevance. Roy [5] provides a description of a number of questions/products that are developed under what they call Situation Analysis. In our case, we believe a number of these products are created at Level 1 while others are Level 2. Level 1 attempts to answer such questions as Existence and Size Analysis (How Many?),

Identity Analysis (What/Who?), Kinematics Analysis (Where?), and When, while Level 2 provides: Behavior Analysis (What is the object doing?), Activity Level Analysis (Build up, draw down?), Intent Analysis (Why?), Salience Analysis (What makes it important?), and Capability/Capacity Analysis (What could they/it do?). We can also argue that Level 2 and 3 are a result of analysis of current data. After this assessment, the next step would be to forecast or project the current situation and threat into the future. We specifically call this function as projection (as defined by Endsley [4]) and show it as a separate capability from Level 2/3 of the JDL. It is true, however that to perform projection one would rely on the current situation and forecast not only those salient activities into the future but also any future impacts or threats. Thus, to summarize, a situation is a snapshot of the aggregated activities at time t. Projection takes the situation and projects or forecasts it to time t + n, where n is some number of time steps. Figure 1 summarizes what we have presented thus far.
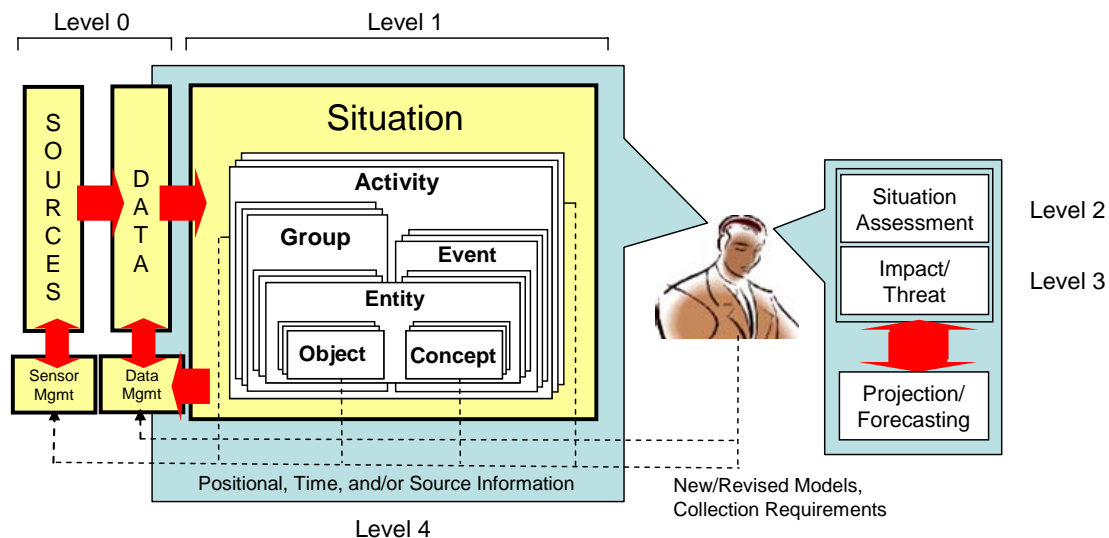

FIGURE 1 – Proposed Refinement of JDL Model

2 Process Refinement

In this next section we discuss what Process Refinement means for Level 2/3 and conceptually how it can be implemented. We also present how it is affected by Projection. The basic definition of Process Refinement as presented above covers two separate but integrated capabilities. For the purpose of our discussion we will divide them into an external and internal process. Externally, we are concerned with providing sensors or collections with positioning information based on forecasted or anticipated movement of objects/entities or groups. The classical example here is the tracking of an object. A common tracking algorithm used in today's system is a Kalman Filter. Kalman Filters provide the ability to forecast where the object could be in one time increment in the future. This position information can then be provided to "better" position the sensor. Theoretically, a similar approach can be done with concepts and groups. Also, since models are typically used to define relationships, one can also use these models for projection. Models that describe activities not only

describe how entities, groups and events are related, they also provide knowledge as to what might happen next and thus can provide positional information for sensor collection. We define models in a generic sense (a body of knowledge or relationships, technique independent). They can be kinematics models describing how a particular piece of equipment behaves, what an object looks like for identification (as in automatic target recognition), one that identifies a specific social group (terrorist cell or a specific military unit or division) or a number of inter-related events that make up an activity.

Now back to our discussion. Level 2/3 is concerned with identification of the current situation, identification of the adversary's capabilities and analysis of the adversary's strengths and weaknesses. This understanding of the adversary is packaged into what is called an adversarial model. In today's environment, models as defined by current doctrine consist of: (1) Doctrinal Templates (illustrate the employment patterns/dispositions preferred by an adversary when not constrained by the effects of the operational environment); (2) Description of Adversary Tactics and Options (a written description of an

opponent's preferred tactics) and (3) Identification of High-Valued Targets (those assets that the adversary commander requires for the successful completion of their mission).

Projection, Anticipation or Forecasting is accomplished by the analyst and supports the development or analysis of possible (1) adversary intent; (2) Courses of Action (COA) – to include a prioritize list identifying the most likely and most dangerous and (3) a set of collection requirements. As part of the process that an analyst performs while developing their situation and impact/threat assessment, they may develop a collection of requirements and identify new relationships (and in turn update their model(s) of the world). As they are developing possible adversarial intents and COAs the analyst determines the key events in each to aid in the determination as to which one of the proposed COAs is unfolding (or not). These key events are then turned into a set of collection requirements and used as part of the process refinement process

The process described above assumes that we have perfect collection and retrieval technology and that we obtain only the data/information that we need to perform our job. No manner the technique, it is prone to errors and depending on how requests are written can either open a huge flood gate or miss that one important piece of data. One must always provide the ability for the analyst to examine existing archives retrospectively to see if additional evidence is available about a certain object, group, event or activity. Existing data found by sifting through the raw data and not automatically delivered by the existing profiles could lead to the profiles being revised or new ones being created.

Internal processes also need to be monitored to ensure that the information processing system is performing as designed. At the object level one can suggest, possibly based on environmental inputs, which source is "better" at that time for tracking or identifying the object or sending the same sensor data to multiple algorithms (running in parallel), coming up with possibly different answers and combining the results in some manner. Similar concepts can be used at the activity level. As previously mentioned a second area is the update of a priori knowledge or models. As new information comes in and new knowledge is developed through the assessment and projection process, the analyst may update existing models or add create new models (regardless of whether it is a new/modified object, group or activity).

3 Conclusion

The purpose of this paper was to present a view, based on a number of years of building systems that describes a more logical functional boundary for the JDL fusion model. The model has served this community well but as time and understanding has progressed, so must the model. We began our discussion with a number of basic definitions followed by a description of various types of interaction between Levels 4 and 2/3. We refined the existing definitions of Level 1 and 2 in hopes to better clarify each of their roles. We also provided a discussion describing a distinction between Level 2/3 as described by

the JDL (for the current situation) and Endsley's concept of projection and how they can jointly exist.

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